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RFID System

Système RFID

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(56) References cited:
WO-A2-01/95242 US-A1- 2006 158 312

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Description

FIELD OF THE JNVENTION

[0001] The present invention relates generally to the field of telecommunication systems, and in particular to implementing radio frequency identification technology using high frequencies.

BACKGROUND OF THE INVENTION

[0002] Radio Frequency Identification (RFID) systems are used in a variety of ways in product tracking, supply chain management, and numerous logistical operations. Applications of RFID tags include replacement of bar codes in inventory management of consumer items, tracking of books in libraries or bookstores, shipping container and truck/trailer tracking, and livestock tracking. In the automotive field, RFIDs are used in car keys to activate vehicles and for tire tracking. Transport payments are enabled by the use of RFID smartcards.

[0003] A typical RFID system consists of the inclusion of one or more small inexpensive tags that contain transponders with a digital memory chip that is given a unique product code. In the case of passive tags, a base station (or reader) emits a signal activating the RFID tag to cause it to emit a signal. The reader can then receive this signal and decode the data encoded therein. As is known in the RFID art, RFID readers transmit RF power to RFID tags. RFID tags are interrogated by, and respond to, RFID readers utilizing a radio-frequency forward link and a backscatter return link. Some RFID readers, for example, the RFID reader disclosed in WO 01/95242, use a first frequency to transmit RF power and a second frequency to transmit and receive data signals. Some RFID tags contain a demodulator which is used to recover a timing (or clock) signal from the signal received from the RFID reader The recovered clock signal is then utilized to generate a value to control a digitally-controlled oscillator that provides clock signal used in the backscatter return link.

[0004] RFID systems have been allocated bands of operation at particular frequencies. As disclosed in US 2006/0158312, the frequency ranges from 10 kHz to 300 GHz- Low-frequency (125 kHz) RFID tags can be used globally without a license. Additional, 900 MHz tags are typically used in warehousing and shipping, while the lower frequencies (125 KHz, 13.56 MHz) are generally used for inventory or shelving operations.

[0005] Low-frequency and higher-frequency RFID systems each have their advantages and disadvantages. For example, it is generally easier and cheaper to generate RF power at lower frequencies. Since many applications require a low-cost RFID tag system, low frequencies are commonly used. However, low frequency systems require physically larger antennas and can result in signal propagation to unwanted areas. Signal processing to correct these phenomena is possible but would make the tags too expensive. The low carrier frequency also puts a ceiling on the allowable data rate. Without the use of more intensive and expensive signal processing techniques it is difficult to approach a data transmission bit rate of 1 kbps per kHz, so a 125 kHz system would top off at around 100kbps data rate transfer, which though in some applications would be more than adequate, in others would be a limitation.

[0006] There is a band of very high frequencies in the 57 — 64 GHz range ("60 GHz band") that is located in the millimeter-wave portion of the electromagnetic spectrum and has been largely unexploited for commercial wireless applications. This spectrum is unlicensed by the FCC in the United States and by other bodies world-wide. In addition to the higher-data rates that can be accomplished in this spectrum, energy propagation in the 60 GHz band has unique characteristics that make possible many other benefits such as excellent immunity to interference, high security, and frequency re-use. However, RFID tags designed for receiving millimetre frequency signals are more expensive than tags designed for receiving low frequency signals. As such, what is needed is an RFID system that can take advantage of the benefits of both low and high frequency signals.

SUMMARY OF THE INVENTION

[0007] Disclosed and claimed herein is a RFID system as recited in appended claim 1.

[0008] Other aspects, features, and techniques of the invention will be apparent to one skilled in the relevant art in view of the following description of the exemplary embodiments of the invention

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 illustrates an example RFID tag;

[0010] FIGs. 2A — 2B illustrate example RFID systems presented for background information;

[0011] FIG. 3 illustrates an ambodiment of an RFID system in accordance with the invention; and

[0012] FIG. 4 illustrates a further example RFID system presented for background information.

DETAILED DESCRIPTION

[0013] One aspect of the invention is an RFID system. In certain situations, it may be preferable to use different radio frequencies in an RFID system. In accordance, a lower frequency may be used to energize an RFID tag, while a higher frequency (e.g., millimetre frequency) may be used to make a range-restricted radio frequency communication. It should be appreciated that references herein to "higher frequencies" refers to frequencies in the millimetre band, which includes all frequencies between 30 GHz to 300 GHz ("millimetre band""). Frequencies in the millimetre band are also known as extremely-high frequencies (EFH). In contrast, references herein to "lower frequencies" includes all frequencies below the millimetre band, and in particular include frequencies centered about the 125 kHz, 900 MHz, 1.8 GHz and 2.4 GHz frequencies.

[0014] Another aspect of the invention is to leverage the near line-of-sight propagation characteristics of millimetre frequency transmissions, while minimizing the power requirements of the RFID tag. Millimetre frequency signals enjoy an inherent security advantage as compared to longer wavelengths that bend around corners or propagate through barriers to potentially unintended territories. The design of the antenna on the tag can make the transmission from the tag highly directive or even alternatively omni-directional. An RFID reader can therefore transmit and receive selectively from a particular asset.

[0015] For example, a millimetre frequency (e.g., 60 GHz) RFID tag may be activated with a lower frequency (e.g., 900 MHz) signal. The RFID tag's antenna may act as a resonant circuit, providing both inductive and capacitive properties, to power up its internal circuits from the received energy. Once powered up using the lower frequency, the millimetre frequency tag may then, according to a background example, transmit a responsive signal at the higher frequency (e.g., 60 GHz band). This arrangement would yield much more location-specific information about asset location than conventional RFID systems.

[0016] In another background example, an RFID system would enable an RFID reader to receive information for a particular tagged asset. Heretofore, activating an RFID reader would have cause every RFID tag within the reader's coverage area to respond. Thus, it would not be possible to identify a tagged asset, and receive the data stored on that particular RFID tag. However, this example permits a user to identify a particular tagged asset, and to receive only the information from that RFID tag. By way of example, a user could point an RFID reader at a tagged asset of interested. Activating the RFID reader would propagate the low frequency transmission throughout the reader's coverage area. However, given the directionality of the return signal (e.g., 60 GHz), only the RF signal from the desired RFID tag will be detected by the RFID reader. As such, a user can identify an asset of interest, and receive asset-specific information in response to a low frequency polling signal.

[0017] Still another background example is a 60 GHz RFID system for implementing Digital Rights Management (DRM) of audio/video content. DRM is the digital management of user rights to content which links specific user rights to media in order to provide persistent control of user activities such as viewing, duplication and/or access. To that end, in one embodiment an RFID tag which transmits in the 60 GHz band can be used to verify the locality of a multimedia device to which a user has requested that DRM-protected content be transferred. DRM compliance can be attained by having the content source (e.g., personal computer, set-top box, etc.) poll an RFID tag embedded in the multimedia device. Given the propagation properties of 60 GHz band signals (or any millimetre band signal), a response from the multimedia device would verify that it is in fact a local device. Similarly, periodic polling could be used to verify that the multimedia device to which the content was copied remains local.

[0018] Given the directionality of millimetre frequency signals, it may be necessary to place multiple RFID tags on a single asset. The plurality of RFID tags may have the same identity number and be placed on different surfaces of the tagged asset. However, doing so may cause interference between the individual RFID tag signals. As such, the RFID tags may be configured to transmit delayed signals back to the reader. In this fashion, a reader would be able to poll multiple RFID tags on a single asset while minimizing interference.

[0019] Another example is to integrate an RFID system with 60 GHz wireless networks. A 60 GHz network may poll appliances attached to it at periodic intervals to assess the presence of new networked clients, and any changes in status of existing networked appliances. There is also significant commercial application in using a 60 GHz transceiver and a synchronous clocking system to authenticate new network appliances and to establish connectivity. New network protocols based on operation at 60 GHz are emerging. This will make it possible to provide truly massive bandwidths, within local areas, at rates of several to tens of gigabits per second, so that massive information sources may be transmitted wirelessly within seconds or milliseconds. The capabilities of massively broadband wireless devices, communicating at carrier frequencies of 600 GHz will reduce the need for multiple and hierarchical storage systems and reduce today's bulky, cumbersome storage devices such as hard drives, large paper texts, CDs and other storage devices in a complex database system.

[0020] In one example, a transmitter antenna in an RFID tag can be much smaller than previously-attainable sizes given the millimetre band frequency of the signal to be transmitted. In particular, wavelengths at 60 GHz is 0.5 mm and antenna dimensions are usually on the order of half a wavelength or less. Because of this, it may be possible to incorporate the antenna and/or entire RFID tag inside a semiconductor device or package. It should be appreciated that a diversity of antennae configurations and polarizations are possible, ranging from omni-directional to narrow beam, and from linear to circular polarizations.

[0021] As used herein, the terms "a" or "an" shall mean one or more than one. The term "plurality" shall mean two or more than two. The term "another" is defined as a second or more. The terms "including" and/or "having" are open ended (e.g., comprising). Reference throughout this document to "one embodiment", "certain embodiments", "an embodiment" or similar term means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, the appearances of such phrases or in various places throughout this specification are not necessarily all referring to the same embodiment. Furthermore, the particular features, structures, or characteristics may be combined in any suitable manner on one or more embodiments without limitation.

[0022] The term "or" as used herein is to be interpreted as inclusive or meaning any one or any combination. Therefore, "A, B or C" means "any of the following: A; B; C; A and B; A and C; B and C; A, B and C". An exception to this definition will occur only when a combination of elements, functions, steps or acts are in some way inherently mutually exclusive.

[0023] Referring now to the figures, FIG. 1 depicts an example RFID tag 100. As previously discussed, the tag 100 may be placed on one or more surfaces of an asset that is to be located and/or otherwise identified. This system comprises a mechanically protective structure **102** which protects an antenna **104** from mechanically harmful bending stresses. The antenna **104** may be made of a metallic material with good electrical conductivity properties. In a background example antenna **104** may be further configured to transmit a signal having a frequency in the millimetre band (e.g., 30 GHz to 300 GHz), which may be in the 60 GHz band. In one example, the antenna is also configured to function as a resonant circuit in response to a lower frequency polling signal (e.g., 125 kHz, 900 MHz, 1.8 GHz, 2.4 GHz, etc.), and to generate an induced electrical current to power the processor circuit system **106** in response. In one example, the processor circuit **106** includes a circuit to detect the incoming polling signal, a simple control processor and a memory to store data values. The processor circuit **106** may be programmed to respond to polling from a reader by transmitting data at a millimetre wave frequency utilizing the antenna **104**. Thus, in a background example the RFID tag **100** may be activated or powered by an RF signal that is lower than the signal at which it transmits.

[0024] In this example, the antenna **104** is mounted independently of the processor circuit **106**, while in other examples the antenna 104 may be attached as an integral part of a semiconductor package or even be an integral part of a circuit etched on a semiconductor substrate. It should be appreciated that antenna **104** may also be a printed loop or wireloop antenna. Moreover, the resonant properties described above for the antenna **104** may similarly be imparted using a separate resonant circuit comprised of an inductor and a capacitor (not shown).

[0025] It should further be appreciated that RFID tag **100** may include a low power 60GHz, oscillator for upconversion. In addition, it may be desirable to provide a degree of antenna beam control due to the high propagation loss and the low power requirement of the tag **100**. Beam control may be provided with a retro-directive antenna,or beam control may be provided by changing the transmission frequency.

[0026] FIG. 2A illustrates as a background example a system **200** comprising a reader **205** which radiates RF energy at a lower frequency (e.g., 125 kHz, 900 MHz, 1.8 GHz, 2.4 GHz, etc.) over a coverage area **210**. The reader **205** is controlled by a system controller **215**. While the system controller **215** is depicted as being remote from the reader, in other examples the controller 215 may be integrated with the reader 205. Moreover, while the power radiated from the reader 205 is shown as being omnidirectional, numerous other radiation shapes and directionality may be used.

[0027] The reader **205** is depicted as being located within an enclosed area **220**, which in one example may be a room or some other confined region. In certain examples, the low frequency transmissions of the reader **205** are able to penetrate the confined area **220**, while higher frequency transmissions (e.g., millimetre frequencies) are not.

[0028] RFID tags **a1 - a4** are also shown within the confined area **220**, which may be attached to corresponding assets. RFID tags **a1 - a4** have RF radiation patterns **225, 230, 235** and 240. In a background example, RFID tags all **a1 - a4** emit a higher frequency signal in the millimetre band (e.g,, 60 GHz band), having RF radiation patterns **225,230**, **235** and **240**. RFID tags **a1 - a4** may be designed similar to RFID tag 100 of FIG. 1. In addition, a separate RFID tag b1 is depicted as being located outside the enclosed area **220**, but still within the coverage area 210 of the reader 205, and as having an RF radiation pattern **245**. While the radiation patterns shown are omnidirectional, they may similarly have numerous other shapes and directionalities. For example, in some embodiments radiation patterns **225, 230, 235** and **240** may be highly directional.

[0029] Given that RFID tags **a1 - a4** and **b1** are all within the coverage area **210**, they will be able to receive the low frequency signal emitted by the reader 205 to power up their electronic circuits. However, only responses from those RFID tags (i.e., **a1 - a4**) within the enclosed area **220** will be received by the reader **205** due to the very high frequency of those signals and their inability to penetrate the enclosed area **220**. Accordingly, system **200** can not only verify the presence of particular assets, but also can determine location-specific information for such assets (e.g., asset is within a particular room).

[0030] Moreover, the fact that the millimetre-frequency responses from the RFID tags **a1** - **a4** are unable to penetrate the enclosed area **220**, the security of the information relayed to by those tags is correspondingly increased. This enables RFID tags to safely transmit sensitive asset-specific information.

[0031] As previously mentioned, multiple tags may be used on an asset when the signal to be emitted is directional. However, in order to prevent the possibility of a data collision, such tags may be programmed to respond with different delays. As such, when the asset is polled, regardless of the orientation of the item, at least one tag should be able to respond, and if more than one tag responds, the reader will still be able to accurately receive such responses. While in one example, the delay period is predetermined, in another example the response delay is a random value. Alternatively, the delay period could be a function of the tag's location on a given asset.

[0032] Still referring to FIG. 2A, in one background example system **200** may be used to implement a Digital Rights Management (DRM) system for protected multimedia content. For example, reader **205** may be contained within a multimedia source (e.g., personal computer, set-top box, etc.), while RFID tags **a1 - a4** and b1 are contained within various multimedia devices requesting that protected content from the source. DRM compliance is attainable since, prior to transferred the requested content, the multimedia content source will poll for the multimedia device. Given the propagation properties of 60 GHz band signal, a response signal will only be received from those requesting devices that are local to the content source. In the background example of FIG. 2A, this means that the content would be transferred to local devices tagged with RFID tags **a1 - a4** , but not to the device tagged with RFID tag **b1**.

[0033] Now referring to Fig. 2B, depicted is an RFID system **250** in accordance with another background example. Two adjacent rooms **255** and **260** are shown, each containing a reader **265** and **270** having propagation patterns **275** and **280,** respectively. In one example, the readers **265** and **270** are connected to a system controlled **285**. Room **255** contains reader **265**, as well as RFID tags **c1** — **c4.** Room 260 contains reader **270**, as well as RFID tags b1-**b4.** In certain examples, RF readers **265** and **270** emit a signal having a relatively low frequency (e.g., below millimetre band), while the RFID tags **b1 - b4** and **c1 - c4.** email response signals having frequencies in the millimetre wave range (e.g., 60 GHz band). RFID tags **b1 - b4** and **c1 - c4** may be designed similar to RFID tag 100 of FIG. 1.

[0034] System **250** may used to identify in which room **255** and **260** a particular asset is located, since a given reader will only receive a response signals from those tags within the same room. Even though the RF signal of readers **265** and **270** propagate across physical barriers, only the response signals from local RF tags will be detected. In this manner, more detailed location information may be obtained due to the limited propagation characteristics of the response tag signals. In addition, the limited propagation patterns for the response tag signals imparts the previously-described security benefits of system 250, without unnecessarily increasing the costs of the RFID tags by - b4 and **c1** - **c4**. since they are activated using the low frequency signals of readers **265** and **270**.

[0035] FIG. 3 illustrates a system **300** in accordance with an embodiment of the invention comprising a reader **305** which radiates a first RF signal at a relatively low frequency (e,g., below millimetre band) over a coverage area 310, and a second RF signal at a millimetre band frequency with radiation pattern **325.** The reader 305 may be controlled by a system controller **315**, which may be local to or remote from the reader 305. Moreover, while the power radiated from the reader 305 is shown as being omnidirectional, numerous other radiation shapes and directionality may be used,

[0036] The reader **305** is depicted as being located within an enclosed area **320**, which in one embodiment may be a room or some other confined region. The low frequency transmissions of the reader 305 are able to penetrate the confined area 320, while its high frequency transmissions (e.g., millimetre frequencies) are not.

[0037] RFID tags **d1** - **d4** are also shown within the confined area **320**, which may be attached to corresponding assets. RFID tags **d1** - **d4** emit a low frequency RF signal which (e.g., 125 kHz, 900 MHz, 1.8 GHz, 2.4 GHz, etc.) has a propagation pattern similar to pattern **310**.

[0038] The reader **305** emits a low frequency signal (e, g., below millimetre band) to energize any tags that are in its coverage area **310.** Thereafter, the reader **305** emits a second higher frequency signal (e.g., millimetre band) that may have pattern **325**. In one embodiment, this second signal may be used to cause any tags within the coverage area **325** to respond. Thus, in the system of FIG. 3 only tag d1 will respond to the reader **305** since it is the only tag within the reader's propagation pattern 325. The response by Tag d1 will be in the form of a low frequency RF signal that may be detectable by the reader **305.**

[0039] In this fashion, system **300** can be used to not only verify the presence of particular assets, but also to determine location-specific information for such assets (e.g,, asset is within a particular room). In addition, system **300** permits a user to identify a particular tagged asset, and to receive only the information from that RFID tag. By way of example, a user could point an RFID reader at a tagged asset of interested. Activating the RFID reader would propagate the low frequency transmission throughout the reader's coverage area, thereby energizing all tags in the coverage area. The second signal, which in one embodiment is a millimetre band signal, will be detected (and hence responded to) by only those tags within its limited range. Thus, a user will be able to identify an asset of interest, and receive asset-specific information.

[0040] FIG. 4 illustrates background example of an RFID system **400** wherein directional antennae are used, and where each of a four assets **410, 420, 430** and **440** have four individual tags attached to it - one on each of its four surfaces. In this example, the system **400** consisting of an enclosed room **450** which is monitored by a reader that is depicted as being in one of two possible positions **460a** and **460b.,** although obviously the reader may be in any other position within the room **450.** As shown, the reader is connected to an optional controller **470.** However, the controller **470** may alternatively be integrated into the reader **205.**

[0041] In system **400,** assets **410, 420, 430** and **440** each have four RFID tags (e.g., tag **100**) affixed to them with highly directional antenna propagation patterns as shown. As the reader moves from location **460a** to **460b,** its transmission pattern shifts from that **of 470a** to **470b.**

[0042] When the reader is in position **460a,** it will detect only the presence of assets **410** and 420 given the directionality of the tags' signals, which may be in the 60 GHz band. Similarly, when the reader moves to position **460b,** only assets **430** and **440** will be detected. Although not shown, the reader may be moved closer to any one of assets **410 - 440** to detect only that particular asset. In this fashion, location-specific information about an asset is possible using RFID system **400.** Moreover, a user is able to identify an asset of interest, and receive asset-specific information in response to a low frequency polling signal by simply placing a reader in proximity to the tag's directional signal pattern.

[0043] Given that multiple response signals from a single asset may interfere with each other, the RFID tags of system **400** may be configured to transmit delayed signals back to the reader. In this fashion, a reader would be able to poll multiple RFID tags on a single asset while minimizing interference.

[0044] As previously mentioned, an RFID tag (e.g., tag **100**) can be operated at a millimetre wave frequency (e.g., 60 GHz), whether or not the reader transmits at this frequency, or at a much lower frequency. That is, the transmitted frequency from the reader may be utilized to energize the circuits on the tag, thereby reducing the cost and complexity of the RFID tag. In addition, the same advantages that accrue for passive RFID tags are also applicable to configurations of a RFID system in which active tags are utilized. Active tags carry a power source, such as a battery.

[0045] While the preceding description has been directed to particular examples and embodiments, it is understood that those skilled in the art may conceive modifications and/or variations. Any such modifications or variations which fall within the purview of this description are intended to be included herein as well. It is understood that the description herein is intended to be illustrative only and is not intended to limit the scope of the invention, which is defined by the appended claims.

Claims

1. A radio frequency identification (RFID) system (300) comprising:

   a radio frequency (RF) reader (305) for transmitting a first RF signal having a first frequency and a second RF signal having a second frequency that is higher than the first frequency;
   an RFID tag (d1) configured to be energized by the first RF signal; and
   a selected physical barrier (320)
   characterised in that in response to receiving the second RF signal, the RFID tag is further configured to transmit a third RF signal at a third frequency which is lower than the second frequency, and the first and third RF signals are able to penetrate the selected physical barrier that the second RF signal is not able to penetrate.

2. The RFID system of claim 1, wherein the second frequency is between 30 GHz and 300 GHz.

3. The RFID system of claim 2, wherein the first and third frequencies are below 30 GHz.

4. The RFID system of claim 1, wherein the RFID tag comprises:

   a processor circuit (106); and
   an antenna (104) coupled to the processor circuit, the antenna being configured to function as a resonant circuit in response to the first RF signal in order to power said processor circuit.

Patentansprüche

1. Radiofrequenz-Identifikations-(RFID)-System (300), aufweisend:

   ein Radiofrequenz-(RF)-Lesegerät (305) zum Übertragen eines eine erste Frequenz aufweisenden ersten RF-Signals und eines eine zweite Frequenz höher als die erste Frequenz aufweisenden zweiten RF-Signals,
   ein RFID-Etikett (tag) (d1), konfiguriert, um vom ersten RF-Signal aktiviert zu werden, und
   eine ausgewählte physikalische Barriere (320),
   dadurch gekennzeichnet, dass in Reaktion auf einen Empfang des zweiten RF-Signals das RFID-Etikett weiter konfiguriert ist zum Übertragen eines dritten RF-Signals bei einer dritten Frequenz , die niedriger als die zweite Frequenz ist, und das erste und dritte RF-Signal fähig sind zum Durchdringen der ausgewählten physikalischen Barriere, die das zweite RF-Signal nicht durchdringen kann.

2. RFID-System nach Anspruch 1, wobei die zweite Frequenz zwischen 30 GHz und 300 GHz ist.

3. RFID-System nach Anspruch 2, wobei die erste und dritte Frequenz unter 30 GHz sind.

4. RFID-System nach Anspruch 1, wobei das RFID-Tag aufweist:

   eine Prozessorschaltung (106), und
   eine an die Prozessorschaltung gekoppelte Antenne (104), wobei die Antenne konfiguriert ist

zum Funktionieren als eine Resonanzschaltung in Reaktion auf das erste RF-Signal, um die Prozessorschaltung mit Energie zu versorgen.

Revendications

1. Système d'identification radiofréquence (RFID) (300) comprenant :

   un lecteur radiofréquence (RF) (305) pour émettre un premier signal RF ayant une première fréquence et un deuxième signal RF ayant une deuxième fréquence qui est supérieure à la première fréquence ;
   une étiquette RFID (d1) configurée pour être excitée par le premier signal RF ; et
   une barrière physique (320) sélectionnée,
   caractérisé en ce que, en réponse à la réception du deuxième signal RF, l'étiquette RFID est en outre configurée pour émettre un troisième signal RF à une troisième fréquence qui est inférieure à la deuxième fréquence, et les premier et troisième signaux RF sont capables de pénétrer dans la barrière physique sélectionnée dans laquelle le deuxième signal RF n'est pas capable de pénétrer.

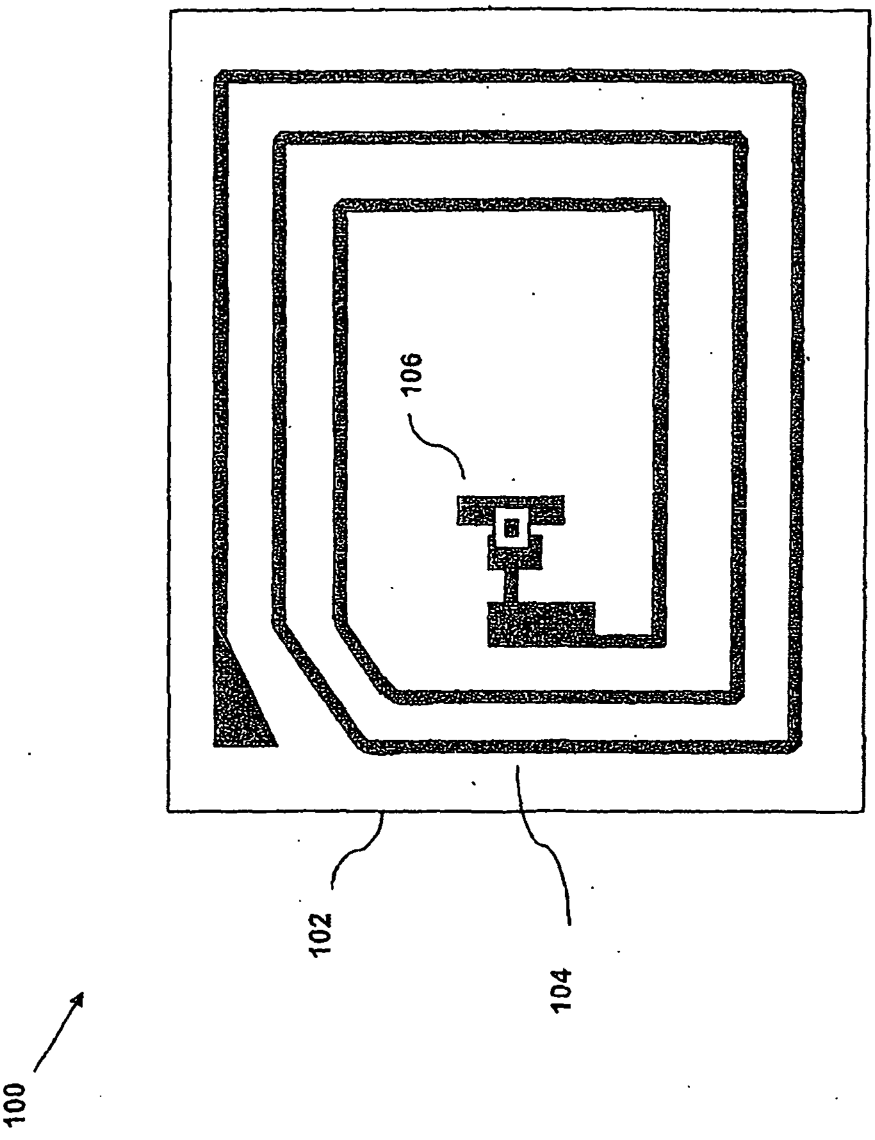
2. Système RFID selon la revendication 1, dans lequel la deuxième fréquence est entre 30 GHz et 300 GHz.

3. Système RFID selon la revendication 2, dans lequel les première et troisième fréquences sont au-dessous de 30 GHz.

4. Système RFID selon la revendication 1, dans lequel l'étiquette RFID comprend :

   un circuit de traitement (106) ; et
   une antenne (104) couplée au circuit de traitement, l'antenne étant configurée pour fonctionner en tant que circuit résonant en réponse au premier signal RF afin d'alimenter ledit circuit de traitement.

FIG. 1



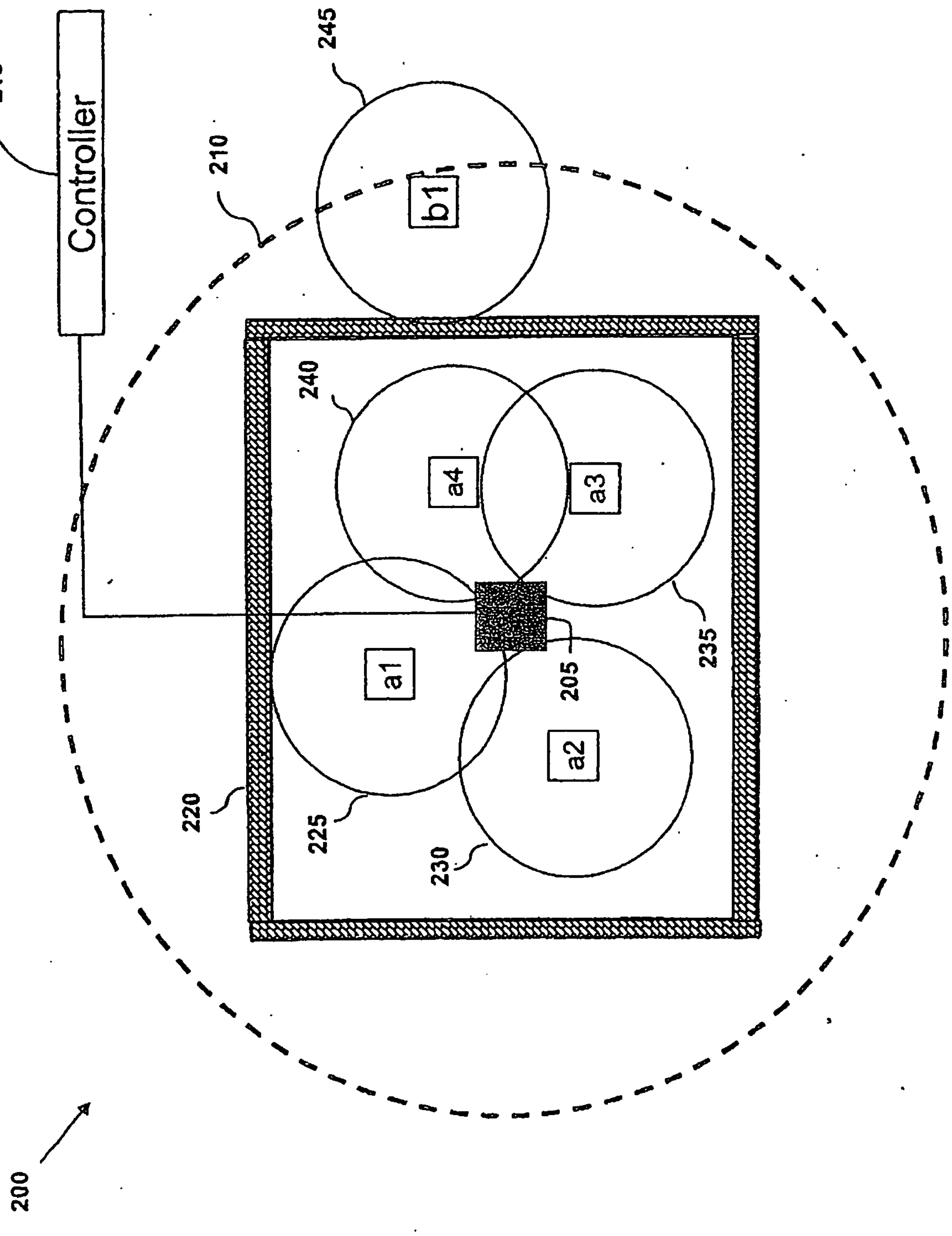

Controller
215
210
245
b1
240
a4
a3
235
205
a1
a2
220
225
230
200

FIG. 2A

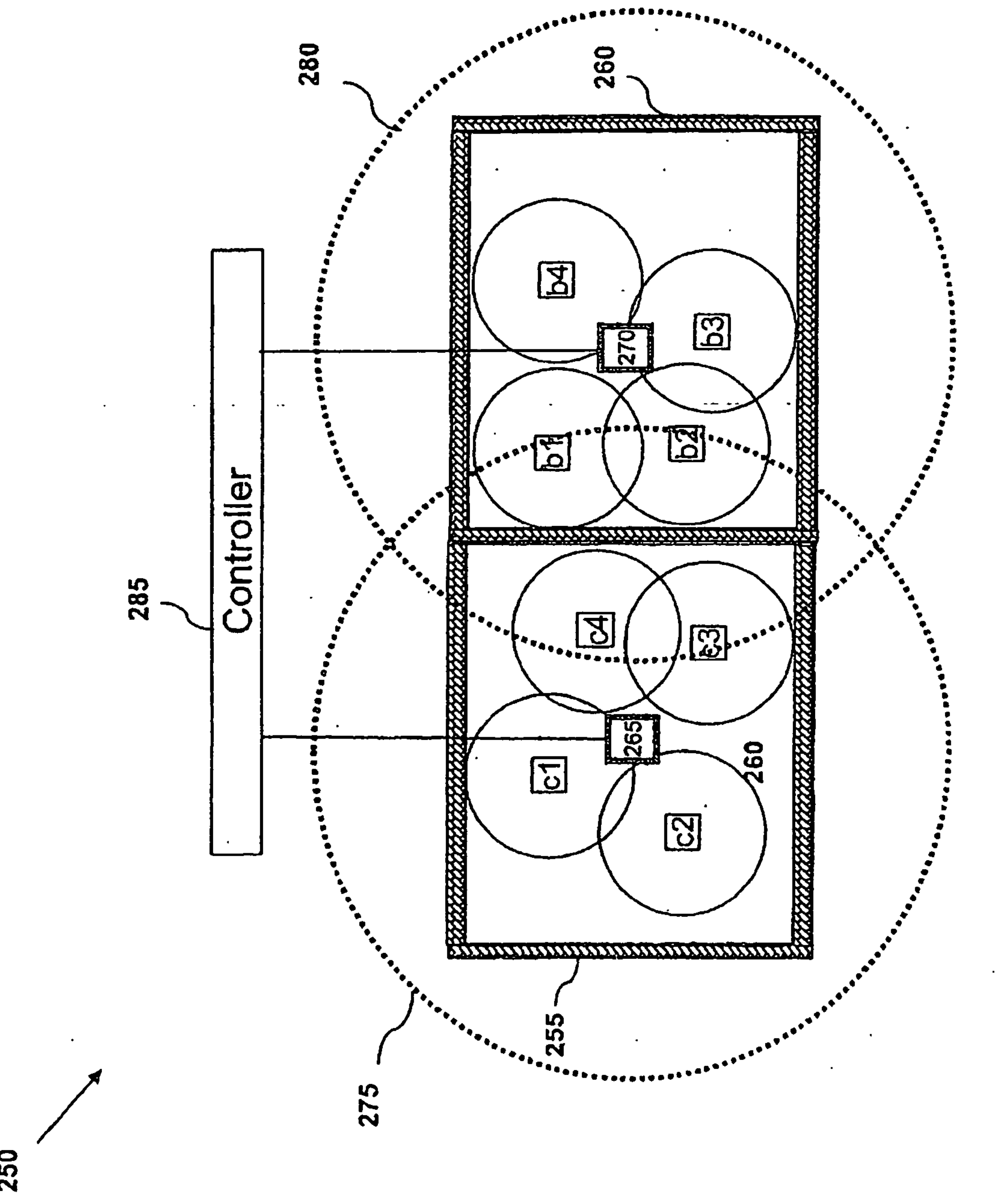

Controller
285
280
260
270
b1
b2
b3
b4
c1
c2
c3
c4
265
260
255
275
250

FIG. 2B

FIG. 3

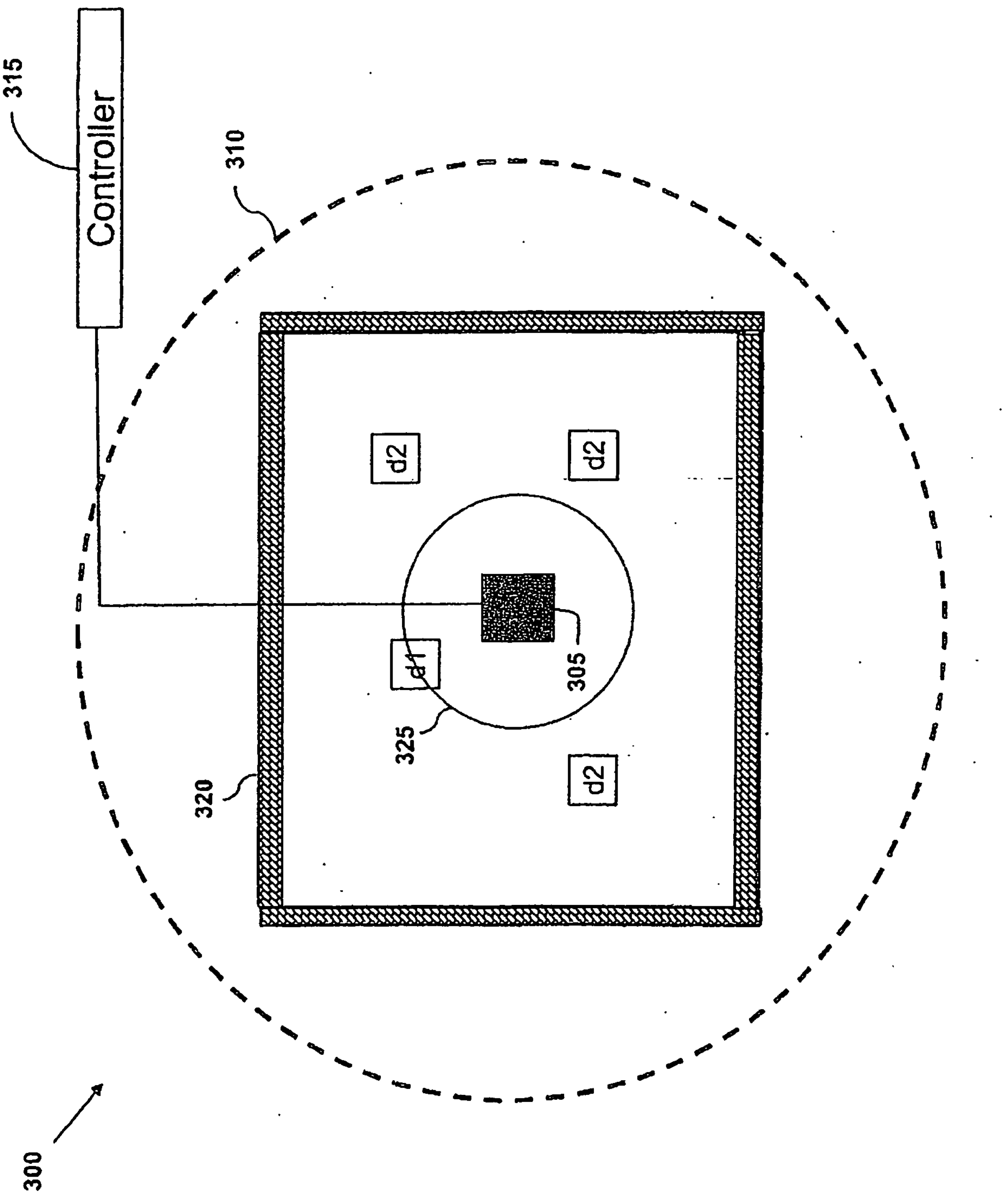
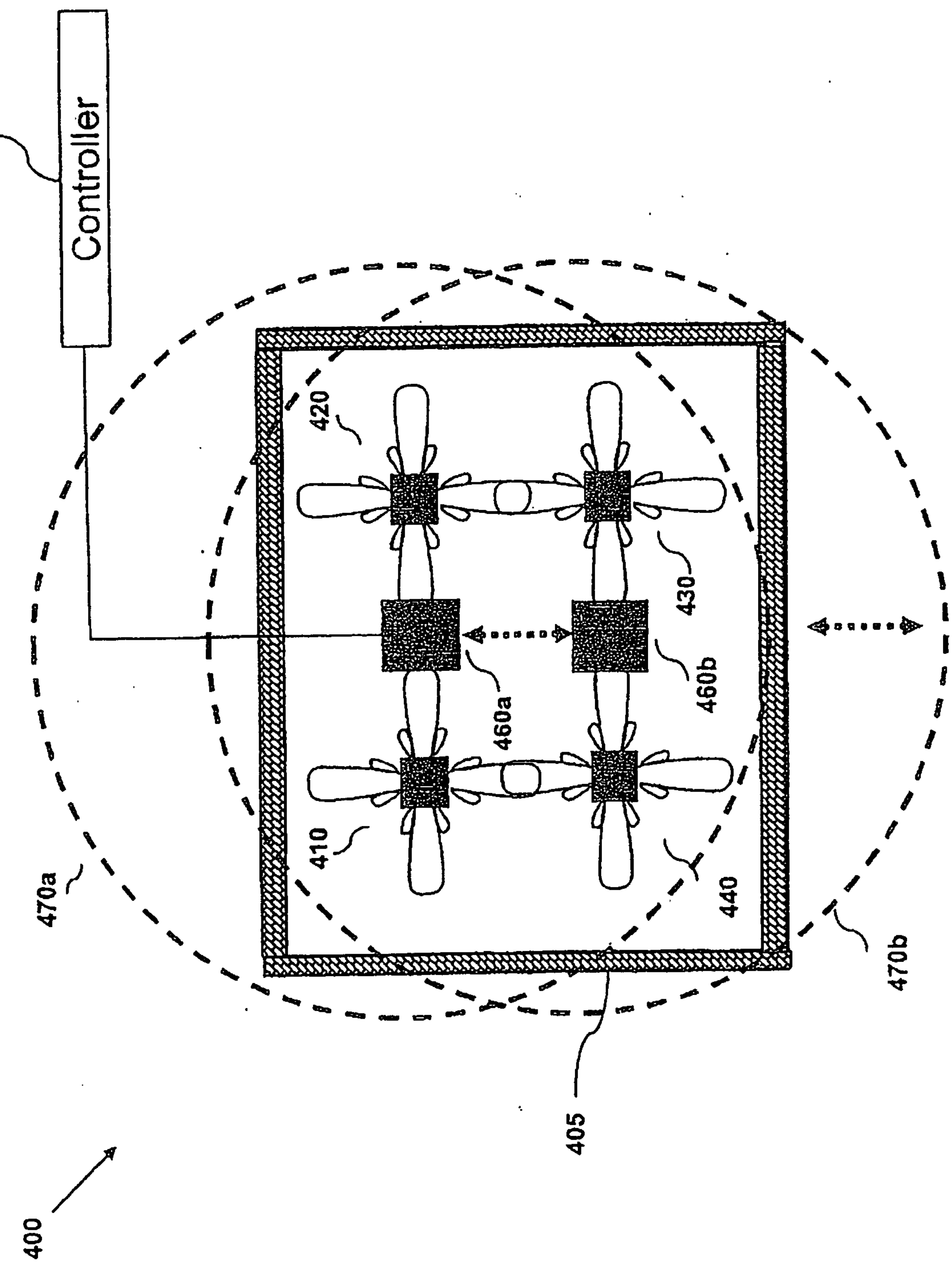


Fig. 4



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 0195242 A **[0003]**
- US 20060158312 A **[0004]**